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UNITED STATES DISTRICT COURT

DISTRICT OF OREGON

PENDLETON DIVISION

OREGON FIREARMS FEDERATION, INC., et al., Plaintiffs, v. KATE BROWN, et al., Defendants. MARK FITZ, et al.,	Case No. 2:22-cv-01815-IM (lead case) 3:22-cv-01859-IM (trailing case) 3:22-cv-01862-IM (trailing case) 3:22-cv-01869-IM (trailing case) **DECLARATION OF ROGER PAULY**

Plaintiffs, v. ELLEN F. ROSENBLUM, et al., Defendants.
KATERINA B. EYRE, et al., Plaintiffs, v. ELLEN F. ROSENBLUM, et al., Defendants.
DANIEL AZZOPARDI, et al., Plaintiffs, v. ELLEN F. ROSENBLUM, et al., Defendants.

Pursuant to 28 U.S.C. § 1746, I, Roger Pauly, declare under penalty of perjury that the following is true and correct:

1. I am over the age of eighteen (18) years, competent to testify to the matters contained in this declaration, and testify based on my personal knowledge and information.

2. I am a tenured, Associate Professor in the Department of History at the University of Central Arkansas, where I have taught for the last twenty-two years. I received my B.A. from St. Olaf College (1988), my M.A. from Villanova University (1992) and my Ph.D. from the University of Delaware (2000), all in History. A true and correct copy of my curriculum vitae is attached as **Exhibit A** to this declaration.

3. I am also personally interested in antique firearms and firearms history. I own a Remington Model 870 shotgun and a Marlin Model 60 target rifle. These were treasured gifts to me from my father and son respectively. More pertinent to history, I also own reproduction models of an 1853 Enfield Rifled Musket and an 1859 Sharps Infantry Model Rifle. These are working firearms based upon nineteenth century designs, but they were built in the past few decades. I have handled and fired a variety of other arms, including a reproduction 1770 cavalry pistol, Beretta 9mm semi-automatic pistol, a .38 caliber Smith and Wesson revolver, several civilian-model AK-47s, a similar model AR-15 styled rifle, and a Kel-Tec SUB 2000 carbine. I have also fired a Korean-War-Era Model M-1 'Garand' Rifle, as well as a Lee-Enfield Pattern Mark IV Rifle, a K98 German Mauser, and US M1-Carbine. The last three of these were World War II era antiques.

4. I am the author of *Firearms: The Lifestory of a Technology*, first issued in 2004 by Greenwood Publishing Group and again in 2008 by The Johns Hopkins University Press. *Firearms* was first in a series of works published by Greenwood that aimed to explore the holistic backgrounds of critical inventions. I also wrote an academic article on the history of the American Firearms industry that appeared in a three-volume collection entitled, *Guns and Contemporary Society* published by Praeger Press in 2016. I have presented a variety of lectures on the subject, including a lecture on the role firearms technology played in the Civil War, available at: https://www.c-span.org/video/?301223-1/state-house-museum-civil-war-symposium. I was similarly hired as a consultant and appeared on the British ITV documentary program *Groundwar: Warrior Weapons*, which premiered in the United States in 2010 on PBS Television. I also appeared in 12 episodes of the documentary series *American Guns: A History of US Firearms*, which premiered in 2017 on Amazon Prime.

5. I have been retained by the State of Oregon Defendants to render expert opinions in this case relating to the history of firearms technology. For my work in this case, I am being compensated at a rate of $125.00 per hour.

6. This declaration is essentially a very abbreviated version of my book on firearms, composed of selected highlights. I did not include footnotes, or endnotes, in my book or this declaration, but I have attached the bibliography for my book as **Exhibit B**.

INTRODUCTION

7. The human body is equipped with only rudimentary defenses such as relatively flat teeth and pathetic claws so unworthy that we call them "fingernails." Our ancestors therefore searched for technology to use as weapons. Over approximately nine centuries, humans developed a particularly effective technology now known simply as the "firearm." Its development has been a gradual and uneven process much like the growth of an individual. Early human missile weapons like spears, slings, and bows represent the distant ancestors of the gun. The crossbow could probably be identified as a more immediate parent, with its telltale lock mechanism and its stock-like tiller. Another parent might well be a medieval Chinese flamethrower known as a "firelance" that used gunpowder as an incendiary. The earliest hand-cannons of Asia and Europe could be analogous to the gun's childhood, while the diverse weaponry of the sixteenth and seventeenth centuries is perhaps reflective of the rapid developments in adolescence. In the nineteenth century new industrial techniques allowed the firearm to surge into a state of adulthood as metallic cartridges, revolvers, breechloaders, and repeating rifles appeared. On the eve of the twentieth century, the recognition that gas and recoil from a shot was capable of driving a gun's reloading mechanism resulted in the rise of both the semi-and fully automatic firearm weapons that predominate today.

8. Like a human, this growth was uneven and erratic. It was not marked by steady progress, but rather through periods of intense development and change followed by episodes of slowing or stagnation. Sometimes future gun designs were anticipated well in advance of the actual technological means needed to create reliable models. In other cases, a firearms designer stumbled, nearly by accident, upon an innovation.

9. While the whole life story of the firearm might appear erratic and unpredictable, some consistent logic lay behind most of the process. No matter what type of missile weapon one is considering, it has to address certain demands or meet certain needs. First, it must be able to hit its target. Small arms manufacturers have thus logically, consistently concerned themselves with promoting accuracy. Accuracy typically drops as distance to a target increases, so linked to the demands of accuracy is the problem of hitting objects at relatively far ranges. Second, it does little good to hit an enemy with a projectile that does not inflict damage. Therefore, the power and strength with which a projectile crashes into its target are important too. A third ingredient to these two factors is rate of fire. Poor accuracy or weak power can be offset to some extent with a weapon that discharges many shots in a short period of time. Thus, the common imperatives of accuracy, power, and rate of fire has guided firearm development at each stage of its lifecycle.

10. Humanity experimented with many projectile weapons throughout the millennia from slings to spears to bows and eventually, firearms. The firearm in turn developed slowly, experiment by experiment and century by century as it increased in lethality. Early models were relatively slow to operate and cumbersome to handle by later standards. The industrial revolution triggered a particularly remarkable expansion of the firearm's capabilities over the course of the nineteenth century. By the end of the World Wars in the following decades, the firearm had

achieved devasting levels of power and accuracy conferring unprecedented lethality to its wielders.

THE FIRST 500 YEARS

11. The firearm's exact birthdate is largely unknown. We can estimate that a very simple version was on the scene in China by the end of the thirteenth century.

12. The basic formula of saltpeter, sulphur and charcoal that formed the basis for gunpowder was devised by Chinese alchemists probably by the ninth century CE although earlier, weaker versions were almost certainly experimented with. Upon ignition, gunpowder undergoes a chemical change that turns it from a solid into a gas of nitrogen and carbon dioxide. This gas expands incredibly fast. Its expansion is a visually spectacular burst of smoke and flame, and it is what gives gunpowder its power.

13. This material was first employed in a device known as a firelance, which was based on a simple tube design (and which would eventually be transformed into a "barrel"). One end of the tube was sealed, and the hollow cylinder was filled with gunpowder. In combat, a soldier would light a fuse at the open end of the tube, which would ignite the gunpowder, and then sparks and fire would shoot violently back out of the open end.

14. Eventually, someone recognized that the potential to cause harm from projectiles flying out of the firelance was far greater than any accompanying sparks. To accomplish this, a "touchhole" was drilled into the closed, rear end of the tube (or "breech"), and a burning fuse was run to the powder through the touchhole. Projectiles were loaded into the other, open, "muzzle" end of the tube.

15. No one can say for certain when the first metal firearm was constructed, but one has been found at the site of a battle that took place in Manchuria in 1288. It is essentially a short

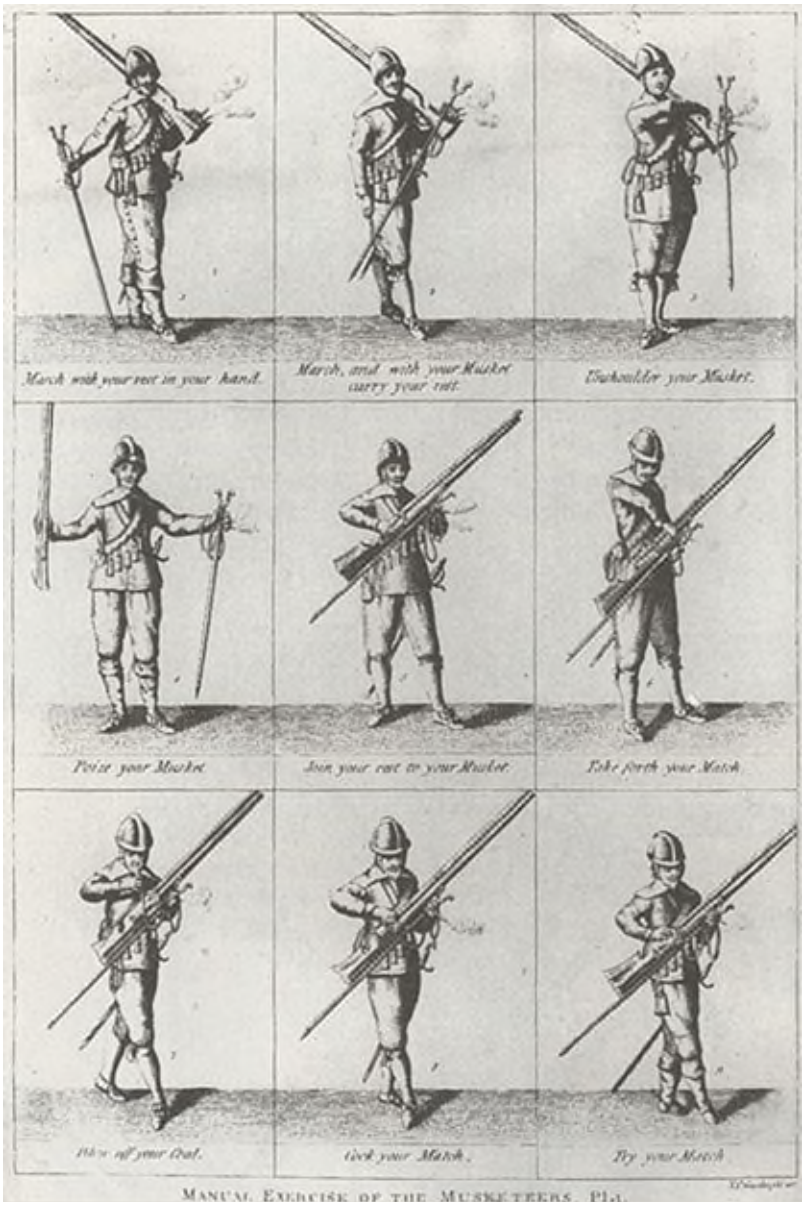
bronze tube with a touchhole in the breech. The oldest evidence of a similar weapon in Europe appears in two separate written sources composed in 1326.

16. At some point in the fourteenth century, alchemists developed a new technique of manufacturing gunpowder known as corning. The new form was significantly more powerful and explosive. Some contemporaries estimate it had three times the explosive potential and a bullet propelled by this product could consistently punch through most armor.

17. By the end of the fourteenth century, larger "artillery" was being developed, and the terms "hand gun" and "handcannon" came into use to distinguish the smaller firearms from the larger weapons. The word "gun" was related to "gin" which was a shorten form of "engine" as in "Siege Engine." Earlier siege engines had been catapults and trebuchets, but now large cannons were taking their place.

18. By the early fifteenth century, weapons appeared that are clearly recognizable as firearms. They used the explosion of gunpowder to fire projectiles known as "bullets." Each one had a metal barrel and most models sported a very simple version of a stock, which was a long, wooden structure set below the barrel and extending behind the breech. This stock allowed for better handling of the weapon and insulated the shooter's hands from the barrel, which could become exceptionally hot after firing. Some of these were even built with gun sights similar to those still used for many open-sighted firearms today.

19. The term "arquebus" became a fairly standard appellation for most hand-held guns by the end of the fifteenth century. "Muskets," in contrast, were initially heavy arms, weighing as much as 20 pounds and sporting 4.5 foot-long barrels. These heavy weapons were aimed by being set on a stake-like device called a "rest." A ramrod was used to push the bullet down the barrel into the breech. Operating the musket took a complex series of steps.



A Seventeenth Century Musket Manual

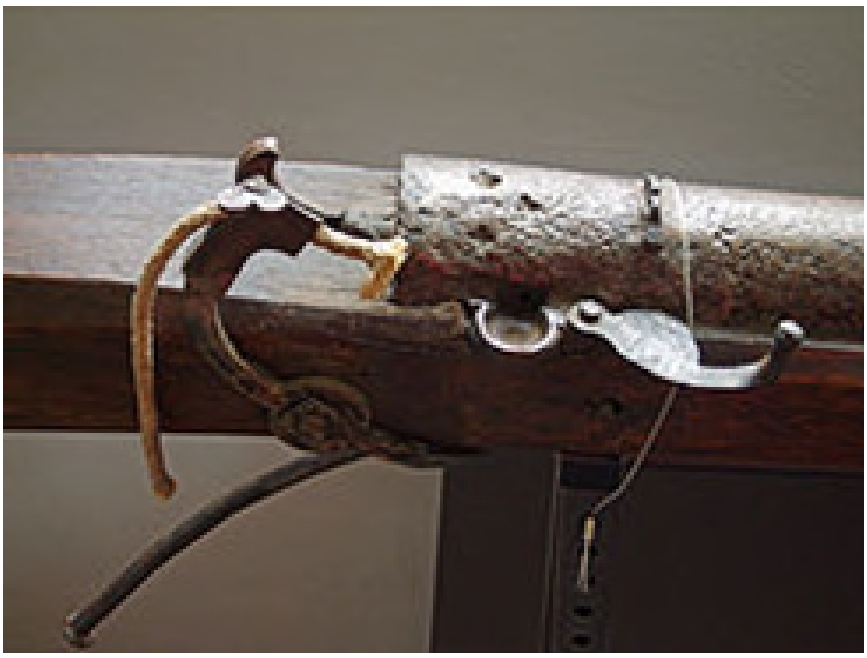
Courtesy of Wikimedia

https://commons.wikimedia.org/wiki/File:Manual_of_the_Musketeer,_17th_Century.jpg

20. Earlier, in the fifteenth century, the task of firing a gun had been mechanized through the use of a feature known as a "matchlock." The most common version of this device featured a metal C-shaped arm. On the side of the stock near the breech was a flat piece of

metal called a lockplate. The upper end of the "C" arm held a smoldering match (a cord covered in saltpeter, sometimes called "match cord"), while the lower extremity was attached to a metal leaf-spring mechanism hidden behind the plate. A metal spring held the "C" in place, and when a large barlike "trigger" was squeezed, the "C" moved downward toward a small basinlike structure. This was the aptly named "flashpan," which was fitted to the outside of the touchhole and filled with a small amount of gunpowder. (This small amount of powder, at some point, came to be called "priming powder," to distinguish it from the main charge in the barrel.) If everything went right, the match at the top of the "C" would ignite the powder in the flashpan, the ignition would travel through the touchhole down into the barrel, and in turn set off the main powder charge.[1] The intricate components of the "C," the trigger, and the leaf-spring reminded people of similarly sophisticated metallic locks that could fix the door to a room or the lid of a chest firmly in place. The word "lock" began to be used to describe the complex firing mechanisms of these weapons.

[1] The origin of the old expression "just a flash in the pan" to describe a disappointing or unfulfilled event arose from cases in which things did not go quite this way.



An early matchlock design. Note the open Flashpan.

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:PS8004046.jpg

21. By the early sixteenth century, simple handcannons had evolved to include all three key components of archetypical firearms: locks, stocks, and barrels.

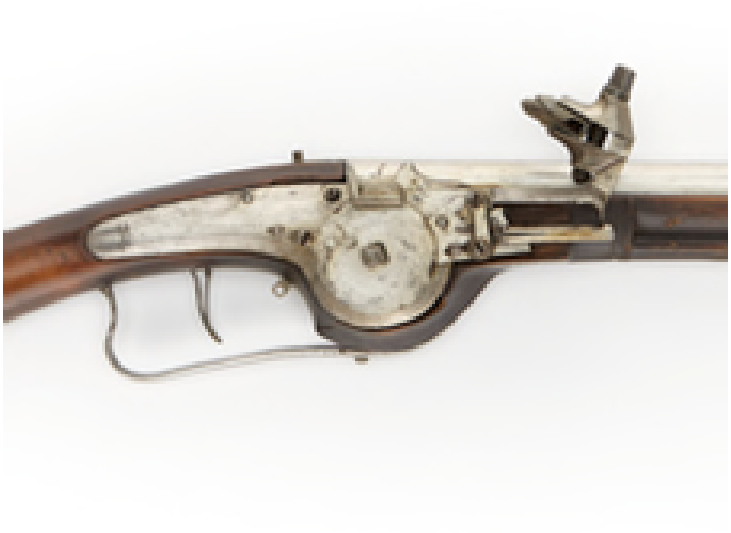
THE SIXTEENTH, SEVENTEENTH, AND EIGHTEENTH CENTURIES

22. In the sixteenth, seventeenth, and eighteenth centuries, a variety of new ignition systems were created, with one—the flintlock—coming to dominate firearms across the world.

23. Pistols also appeared in noticeable numbers during this period. Although some matchlock pistols are known to have been produced, the development of pistols was largely dependent upon the advent of a new kind of ignition, known as the "wheel lock." Written references to wheel lock weapons began to appear in the early sixteenth century.

24. In this system a mechanical wheel spun in place while its serrated edge ran against a piece of flint-rock, somewhat like a modern lighter. The stone was held in a jawlike clamp attached to a hinged arm, known as a "doghead." The shooter prepared the lock by using a

spanner or wrench-like device to wind a lug fixed to the axis of the wheel. This action wrapped a very short chain around the wheel as it turned. After being cranked, the whole thing was held in place by the nose of a metal sear, which popped into a hole drilled in the side of the wheel. As the shooter prepared to fire, the cover was pushed away from the flashpan, and the hinged doghead was manually swung down against the top of the wheel. When the trigger was pulled, the mainspring was allowed to reassert itself, thus pulling the chain that spun the wheel. The wheel rotated, with its serrated edge spinning against the flint, which is an exceptionally hard rock. Tiny bits of metal were sheared away by the flint resulting in a shower of sparks that set off the priming powder.



A Wheel Lock in the Firing Position

Courtesy of Wikimedia

https://commons.wikimedia.org/wiki/File:Wheellock_mechanism_01.png

25. The wheel lock system was complicated, delicate, and prone to breakage. These weapons demanded more craftsmanship to make and more money to produce than matchlocks. Therefore they were not used in huge numbers by common troops in Europe or elsewhere.

Matchlock weapons remained the norm for foot soldiers throughout the fifteenth, sixteenth, and seventeenth centuries.

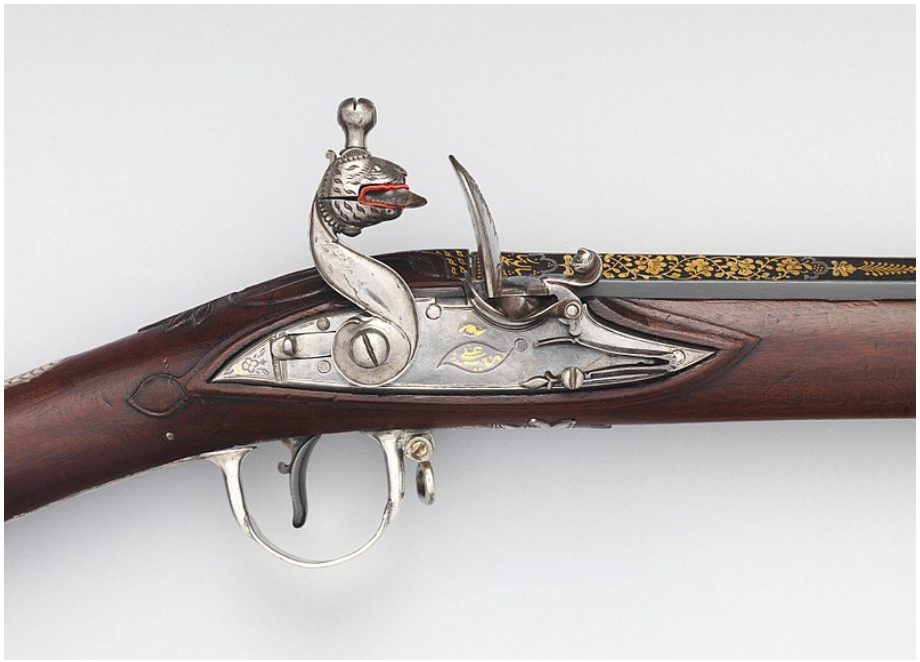
26. That said, a wheel lock pistol had no troublesome, smoldering match cord to kept lit and the firearm could hang from a belt or a saddle, ready at a moment's notice. These arms uniquely provided mounted troops of the time with the means to shoot back at the arquebusiers and musketeers who were wreaking so much havoc on their ranks—although they had only a very short firing range. It has been estimated that cavalry may have had to close to within five paces of the enemy in order for their wheel lock pistols to work at full effect.

27. If a person could afford one, wheel lock pistols also had some role to play in the realm of self-defense. The wheel lock pistol could stay at rest for a long time and was much easier to carry and conceal than a cumbersome matchlock musket. This method carried some risk as early gunpowder (known as "black powder" today for reasons explained below) is highly corrosive and if left in a firearm too long it can eat away at metallic parts, including the barrel. A wise firearm owner was careful to avoid leaving a weapon loaded for too long.

28. Near the very end of the seventeenth century, the major powers of Europe began switching from their matchlock arms to firearms with a "flintlock" ignition device.

29. "True" flintlocks first appeared in France between 1610 and 1620. The device worked rather like a wheel lock, in that it had a doghead—by now known as a "cock" instead, for its beak-like appearance—holding a piece of flint, which the shooter would pull upward and backward and lock into an upright position prior to firing. Pulling the trigger caused the cock to fall down and forward; the attached flint would then strike an L-shaped device, which contained both a "battery" (a stationary piece of iron) and a flashpan cover. The falling action would

simultaneously cause the flashpan cover to open and create sparks by striking the battery, thus igniting the exposed priming powder, which in turn ignited the main charge through a touchhole.



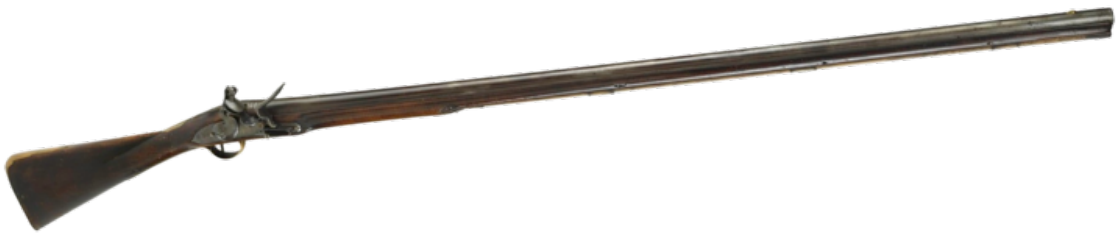
A flintlock mechanism, in the firing position.

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Flintlock_Blunderbuss_MET_DP165769.jpg

30. Flintlock ignitions dominated firearm technology until a new system, the percussion-cap, prevailed in the mid-nineteenth century.

31. A superb example of an eighteenth-century musket was a British model widely known as the "Brown Bess," that used flintlock ignition. By this time, muskets had shrunk in size and weighed only about ten pounds, which is still quite heavy by modern standards. The design was fairly simple: It had a 46-inch-long barrel fixed to a walnut stock, with brass furniture (that is, functional niceties like the trigger-guard). Most models also came with an iron ramrod. It did not have a rear sight, a testament to the gun's lack of accuracy. It has been claimed that 120 yards was the average distance at which projectiles fired from a musket would strike the ground due to a rapid loss of velocity. Most firearms of this age were only reasonably accurate at around

50 yards or less. The muskets of the time, such as the Brown Bess, were not really built with an eye to individual marksmanship. The idea was for dozens of these weapons to be fired at once at mass formations of troops. The Brown Bess was a ubiquitous pre-industrial weapon that was found wherever the British Crown marked its presence, from Georgia to Gujarat. Nonetheless, it was not particularly distinct in design or function from dozens of similar flintlock muskets such as the French Charleville, the Prussian Potsdam, or the Russian Tula. All were single-shot, muzzle-loading firearms.[2] In addition, there were often shorter "carbine" versions of these weapons which were easier for cavalry to use.



A Brown Bess Musket

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Richard_Wilson_Brown_Bess_Musket_tranparent.png

32. These muskets all operated in a similar manner. By the late-seventeenth century, individual paper cartridges, containing both pre-measured portions of gunpowder and round lead bullets, known as "balls," were in wide use. A paper cartridge was opened with one's teeth, and a small portion of the charge was poured in the gun's pan to prime the weapon. The rest of the powder went down the barrel with the ball. The paper tube could be rammed to pack the charge

[2] Some writers have used other names for smoothbore weapons than "musket" but for the purpose of this declaration, a musket is defined as any muzzle-loading smoothbore long arm.

more tightly, or simply discarded. Troops carried anywhere from 20-40 of these lightweight paper cartridges in a leather purse (or "cartridge box"). With some training and practice, a soldier could learn to fire a musket approximately three times per minute.

33. While flintlocks were more difficult to load and fire than a modern firearm, of course, they were relatively easier to use and service than a matchlock or a wheel lock. They did have a high incidence of misfire (failure to fire), though. It has been estimated that in wet or humid weather, for example, as many as 50% of the flintlocks in a line of muskets might fail to fire properly.

34. Nonetheless. the flintlock musket enjoyed a widespread reign as the predominant gun design for about a century and a half. It was the most common firearm in North America at the time of the drafting of the Constitution of the United States of America.

THE NINETEENTH CENTURY

35. Firearm technology saw a relative profusion of innovations in the nineteenth century that produced exponential changes in accuracy, power, and rate of fire, as well as in the reliability of firearms. Two of the firearm's vital components, the barrel and the lock, would drastically change. "Rifled," as opposed to smoothbore, barrels came into wide use, increasing firearms' accuracy many times over. Lock systems also changed, dramatically increasing the dependability and usefulness of firearms across a variety of conditions. By the end of the century, these developments—coupled with advances in manufacturing technology, in general, and in cartridge and even gunpowder design—produced firearms radically more capable of killing both animals and people efficiently.

RIFLING & EXPANDING BULLETS ("MINIE BALLS")

36. The manner through which a quarterback throws a football offers a good analogy to explain the concept of rifling. The quarterback grasps the ball with his or her fingers on one side

and thumb on the other. If the throw is made properly, the thumb will release first, followed by the other four fingers, which roll more gradually off the ball as the arm swings forward. This rolling motion will cause the ball to spin in midair, increasing the range and accuracy of the throw. The ball performs better due to its spinning action—masters can make throws of mind-boggling precision.

37. Around the end of the fifteenth century, a gunsmith cut grooves in a curved, spiraling manner inside a barrel, perhaps as an experiment. It was discovered that lead balls shot from such barrels traveled in a far more accurate fashion.

38. The technique came to be known as "rifling." It was not easy; forging a plain smoothbore barrel was long and arduous work, let alone making one with spiral grooves cut into its inside surfaces. Economical mass production therefore had to await a few centuries for advances in manufacturing techniques. Rifles were also very slow to load— requiring approximately three minutes per shot or "round" (the term is from the shape of the round ball). The reason for this slow-load was because in order to get the projectile to spin, the bullet or ball had to grip the grooves inside the barrel. Therefore, the ball needed to be slightly larger than the bore (or diameter) of the barrel, or encased in a greased, cloth "patch." Loading such an over-sized bullet was a challenge as it had to be jammed into and down the barrel, often with the assistance of a small wooden mallet. For these reasons, rifles were slow-to-operate, expensive weapons that remained in the hands of a wealthy elite throughout the sixteenth and seventeenth centuries. Because of this, the vast majority of firearms continued to be "smooth-bore" with no rifling inside the barrel.

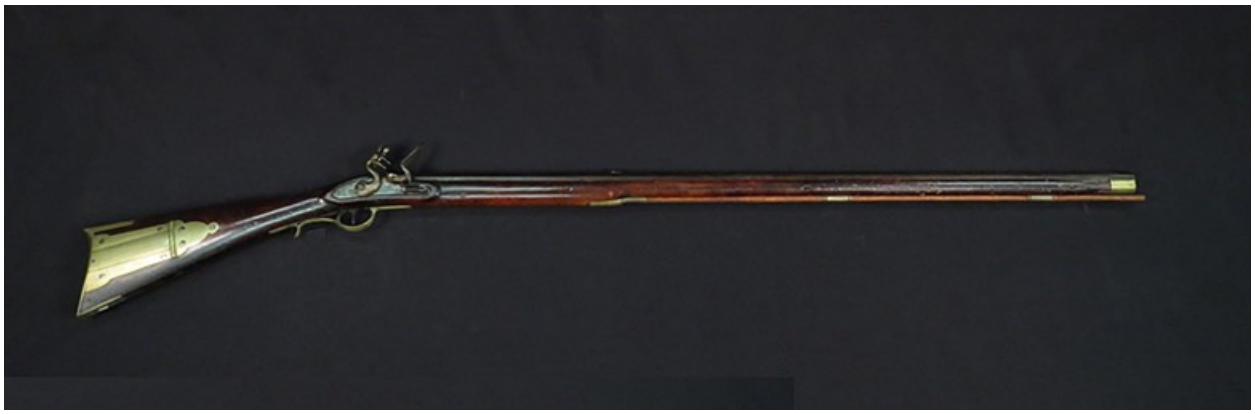
39. Although much of the firearm's story is linked to warfare, the earliest rifles did find an important role in the field of hunting, especially in America. Rate of fire is not a particularly

important factor while pursuing most game. A hunter was likely to only get one shot at a swift stag, and therefore, the difficulty of loading a rifle was worth the improved odds of hitting the animal on the first shot. Although hunting was largely the preserve of the landed classes in Europe, in the New World hunting was customary for both the indigenous populations and the European settlers. German settlers in Pennsylvania in brought their "Jaeger Rifles" with them from the Old World, "jaeger" meaning "hunter" in the German language. Over the course of the eighteenth century, newly-built jaeger rifles began to be equipped with longer barrels that created increased muzzle-velocity. By the middle of the eighteenth century these weapons evolved into the famous "Pennsylvania rifle" that saw service in the American War of Independence. Towards the end of the century as the frontier moved further west the weapon grew in length and used a smaller diameter (or caliber) bullet, perhaps to save on lead. This modified version of the weapon eventually came to be known as a "Kentucky rifle" in the wake of the War of 1812.

40. Rifling could also be employed in pistols. Like the musket, speed of reloading was considered essential in a military pistol, so those weapons continued to use smooth-bore barrels. But pistols with rifled barrels could be employed in target shooting, for self-defense, and in the nefarious fashion of dueling. In these situations, fast reloading was less important or practical than an accurate initial shot.

41. Rifles saw some service in both the American War of Independence and the War of 1812, even playing a decisive role in the frontier-battle at Kings Mountain, South Carolina in 1780. However, their role was not critical in combat due to their slow re-load time. Instead, they functioned in a skirmish capacity and even as something of a terror-weapon because they allowed marksmen to pick off enemy officers. Unsurprisingly, the rifle took on an exaggerated threat in the minds of British commanders and, in the American War of Independence, the UK

responded to this threat by hiring mercenary rifle-equipped "Jaeger" troops from several German states and even raising their own rifle units. Nonetheless, the application of rifles to armed conflict remained subordinate to the smoothbore musket in both the American War of Independence and in the War of 1812.



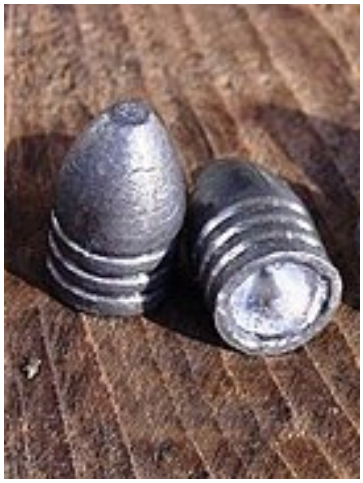
An American Rifle from 1808

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Virginia_Manufactory_1808_Contract_Flintlock_Rifle-NMAH-AHB2015q037944.jpg

42. It should be kept in mind that both classes of weapons, smoothbores and rifles remained single-shot weapons in the late eighteenth and early nineteenth centuries.

43. The early nineteenth century witnessed several attempts to advance bullet technology and faster reloading of rifles. Around 1850 a solution was finalized that came to be called a "minie-ball" or "mini-ball" (after one of its inventors, Claude-Etienne Minie). The minie-ball was closer to the now-familiar "bullet" shape, rather than the older ball. It had a hollow cavity at the base of the bullet which nestled against the powder charge when loaded. The force of the charge would push into this cavity and expanded the rear of the bullet, driving its sides into the rifled grooves. Since these minie-balls expanded upon firing, they could be made

with a slightly *smaller* diameter than the barrel bore, and this greatly sped up the muzzle-loading process. Now rifles could be reloaded almost as fast as a smooth bore.



Two Minie Balls

Courtesy of Wikimedia

https://commons.wikimedia.org/wiki/File:Minie_Balls.jpg

44. Soon thereafter, enormous numbers of rifles were produced for military purposes, such as those built at the Royal Small Arms Factory in Enfield, England. This weapon was informally known as the Enfield Rifled Musket and by 1865 it had seen use from Russia to India to Texas. These arms remained single shot-weapons, but enjoyed significant range and accuracy advantages over smoothbore muskets: In one test, a large target could be repeatedly hit at a range of 800 yards, and even moderately skilled shooters could consistently hit man-sized targets at 200 yards.

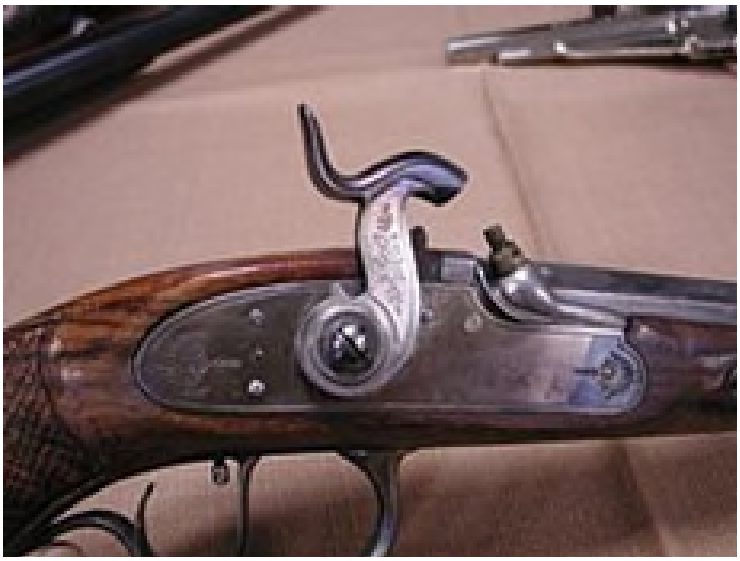
45. About a half million Enfields were ultimately imported to the United States for use in the Civil War. The Union built nearly 1.5 million more of a similar, American-made model loosely known as a "Springfield" after the famous armory of that name in Massachusetts. Both the Enfield and the Springfield were also equipped with an ignition system far more reliable than that used by the Brown Bess.

PERCUSSION LOCKS

46. Around the turn of the nineteenth century, a Scotsman, Alexander John Forsyth, discovered that highly volatiles substances, called fulminates, could be stabilized by mixing them with charcoal, sulphur, and other materials; but that they would still ignite when struck directly with a hammer. Using this discovery, he devised a new system that ultimately superseded the flintlock. Forsyth's somewhat-complex "percussion lock" used a hammer mechanism to ignite a minute amount of fulminate to set off the main powder charge in a firearm.

47. This development rather quickly led to something called the percussion cap. A touch of mercury fulminate compound was set inside a tiny, cheap copper or brass cup-like structure called a "cap," perhaps due to its similar appearance to headwear. The cap could be slipped over the top of a simple small cylindrical "nipple" that had a tiny hole drilled through it lengthwise. The nipple's hollow center led directly into the touchhole. When the hammer snapped down on the top of the cap, the fulminate exploded, and with nowhere else to go, the flame burned down the touchhole into the main powder charge. This hammer-and-nipple system of percussion was simple to construct and was quickly replaced Forsyth's more complicated version.

48. Digging around in one's pocket or "cap box" for a cap was not always quick or convenient, and the caps would sometimes explode, hazarding the shooter's eyes with a shower of metal fragments. But the percussion cap lock system was far less prone to misfire than the flintlock. Being almost entirely enclosed, it was also much more resistant to foul weather. Thus, when only 50% of flintlocks might actually fire in wet weather, 99% of percussion-cap guns would discharge. By 1840, the United States, Britain and France had all adopted the percussion lock for new military arms.



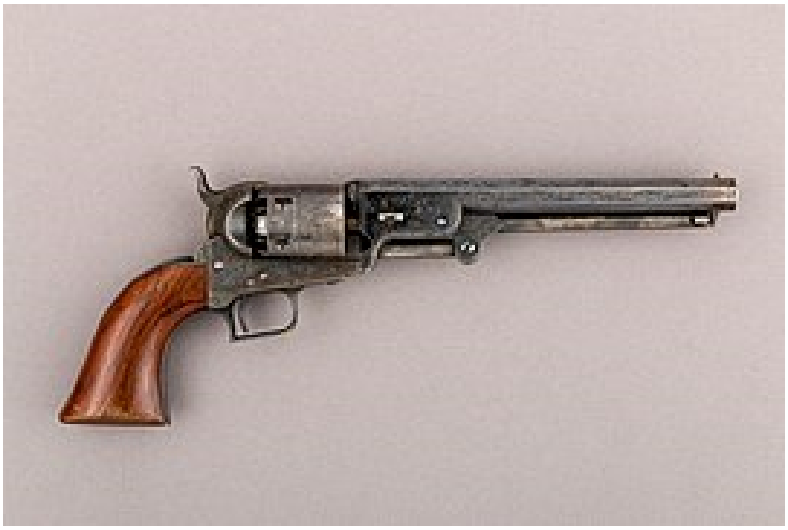
A Percussion Lock. Note: there is no percussion cap on the nipple in this image.

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Perkussionsschloss-Le_Page-in-Laderast.jpg

REPEATING ARMS: REVOLVERS

49. Like so many other modern innovations, the revolver was based on older concepts that predated the famous American inventor, Samuel Colt, by centuries. One Venetian matchlock firearm that used three rotating barrels, for example, has been dated to the 1540s. The concept of a revolver with just one barrel, but rotating breech chambers—a "cylinder"— also dates to at least the sixteenth century. But these early revolvers had to be turned by hand and reprimed (new powder added to the firing pan) after each shot. There was a serious problem with expanding gas leaking through ill-fitting parts. Loose machinery work or worn parts allowed stray sparks from the chamber being fired to find their way into other loaded chambers, sometimes with disastrous results. In the best-case scenarios these loose parts resulted in a loss of propulsion for the bullet. Such pre-industrial revolvers remained experimental. It would require the precision manufacturing of the nineteenth-century's industrial age to make this design effectually functional.

50. The new percussion lock system and advances in precision manufacturing offered the opportunity to re-visit the revolver design and this is exactly what Samuel Colt did. Colt's particular application, patented in 1836, was so successful that countless later enthusiasts credited the gunsmith with actually inventing the revolver. Colt's basic system simply fixed a percussion nipple onto a slight recess at the rear of each individual cylinder chamber. The enclosed nature of the percussion-cap ignition along with the recessed nipples greatly reduced the chance of other cylinder chambers accidentally discharging. He also added a mechanism that rotated the cylinder automatically and lined up a new chamber each time the hammer was cocked.



An 1851 Model Colt Pistol

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Colt_Model_1851_Navy_Percussion_Revolver,_serial_no._2_MET_LC-68_157_2-015.jpg

51. This effective "cap and ball" revolver significantly increased firearms' rate of fire—whereas single-shot flintlock arms might be discharged about three times a minute, a Colt Revolver could now fire six aimed shots in under twenty seconds or less. Reloading the six-shots, however, was a considerably slower process, involving multiple steps for each empty chamber.

The pistol chambers were loaded individually through the front along the side of the cylinder, initially as loose powder and shot, and later in paper cartridges. Separate percussion caps had to be fitted to all six nipples. The whole process could take as many as 24 steps.

BREECH-LOADING RIFLES

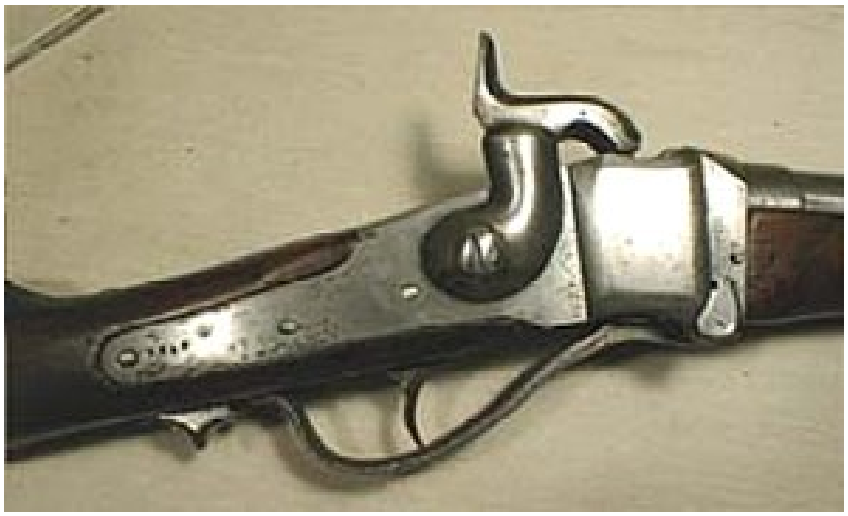
52. Another older idea that was revisited in this new age of technological development was the breechloader. The basic idea of a breechloader is to have a section of the rear of the barrel (or "breech") open up. This would allow a cartridge to be more-easily inserted into the base of the barrel before the breech is re-closed. If made functional, this design could alleviate the burden of ramming a tight-fitting bullet and greatly ease the loading process. The idea had been around since the late Middle Ages, but, like the early revolvers, these designs tended to leak excessive gas and/or explode and remained limited in popularity.

53. Gunmakers like the American, John Hall, began developing somewhat-safer breechloaders by the 1830s, but they still remained-less reliable than the older muzzle-loaders and received a cool reception from soldiers. Today, antique Hall Rifle are fired with a certain degree of trepidation. It must be noted however, that Hall was exceptionally good at precision manufacturing. In the 1820s and 1830s, his work at Harpers Ferry Armory resulted in the most modern industrial equipment and production techniques available at the time. He pioneered an exceptionally high degree of standardization in firearm parts which allowed for some of the success Colt enjoyed (as note above).

54. In 1853, fellow-American, Christian Sharps, significantly improved upon existing designs by creating a special breech seal. This consisted of a movable metal "obduration" ring that was approximately the same size as the diameter of the barrel. This ring was recessed into a sliding block of metal at the rear of the barrel called a "breechblock." When the gun fired, gas from the charge itself was forced under the edges of the ring and drove it against the rear of the

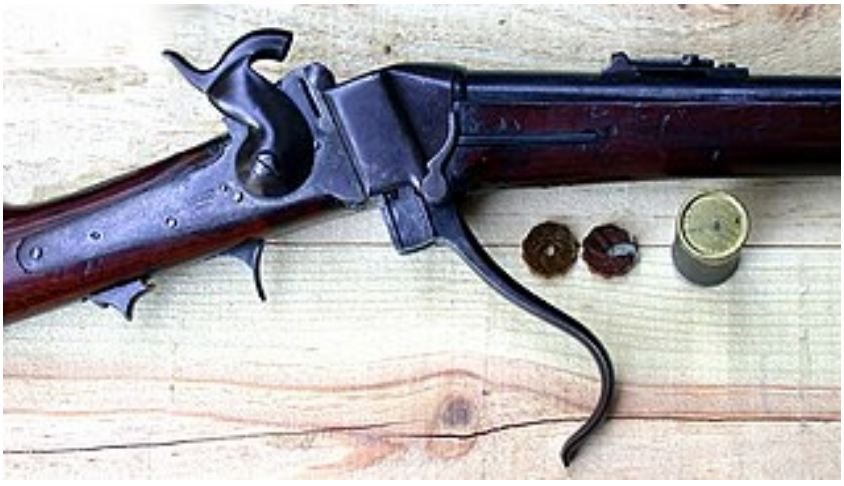
barrel. In this clever, circular system, the force of the expanding gas effectively helped seal the force of the expanding gas.

55. Breechloading indeed significantly increased rate of fire. A report from the U.S. secretary of war in 1859, for example, estimated that "[w]ith the best breech-loading arm, one skillful man would be equal to two, probably three armed with the ordinary muzzle-loading guns." Reloading had become a much quicker process with these weapons, however they still required each cartridge to be loaded one-by-one.



A Sharps Breechloader with the Breech in the Closed Position

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Sharps_Carbine_close-up.jpg



A Sharps Breechloader with the Breech in the Open Position

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Sharps_Rifle_Action.JPG

56. It has been estimated that over 100,000 (single-shot) Sharps breechloading rifles saw action in the Civil War, mostly by cavalry which was considered something of an elite branch of service. The vast majority of infantry in this conflict, however continued to use the tried-and-true muzzle-loading weapons.

THE SELF-CONTAINED METAL CARTRIDGE

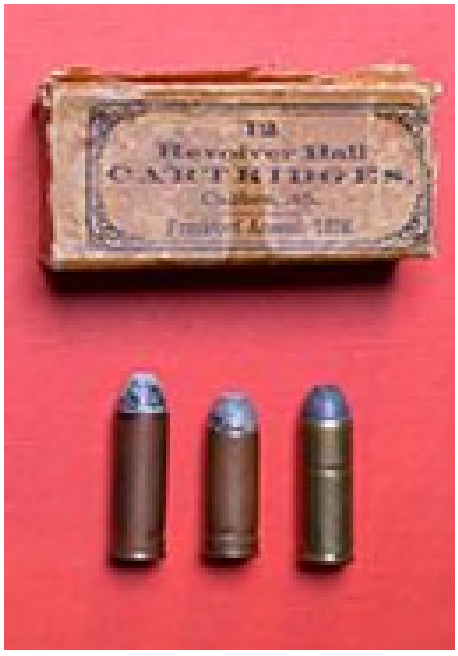
57. Around the same time Sharps' breechloaders came into being, John Forsyth's work with fulminates was being put to new use in America in metallic self-primed cartridges patented by Horace Smith and Daniel Wesson.

58. Earlier, around 1810, Samuel Johannes Pauly of Switzerland, impressed by Forsyth's recent work, recognized that Forsyth's fulminate did not have to rest in the lock but rather could be fixed to an actual cartridge directly. Pauly devised several types of ammunition utilizing metal casings fitted to the rear of a traditional paper cartridge. A small bit of fulminate was fixed in a miniature pan on the center back of the metallic casing and ignited by means of an internal metal spring-driven "firing pin" instead of a side-mounted percussion hammer. Pauly's work was not cost-effective at the time and his designs failed to gain popularity in his lifetime. It was decades before the metallic cartridges he had pioneered were reconsidered.

59. Eventually, though, in the 1850s Horace Smith and Daniel Wesson began developing a low-cost metal cartridge that was tipped by a bullet that was wrapped in a longer brass tube called a "jacket" that was filled with powder. Fulminate for ignition was packed into the rear-rim of the metal cartridge. The percussion ignition system was now an inherent component of this

"rim-fired" cartridge and the need to fumble for a separate percussion cap was eliminated. Smith and Wesson designed a line of light-caliber pistols beginning in 1857 that used this ammunition.

60. By 1871 their competitor, the Colt Company, produced its first breech-loading metallic cartridge-firing pistol modeled heavily on its earlier percussion "cap and ball" revolvers. This particular gun was not a commercial success, but Colt's next effort, the Single Action Army Model of 1873, would go on to become one of the most famous and distinct revolvers of all time. Cartridges of .45 caliber were loaded one by one through a hinged feed slot or "gate" in the rear of the cylinder. Incidentally, the colloquial term "forty five" for some pistols comes from the diameter of the bullet, in this case, .45 inches. Similarly, a "thirty-eight" would use a .38 inch-wide bullet while a "twenty-two" bullet was a petite .22 inches in diameter. The Model 1873 could be rid of its empty .45 cartridges in a reverse loading-motion with the assistance of an ejector rod. This model of revolver was purchased in large numbers all over the country and overseas. The weapon earned a number of nicknames, including the "equalizer" and the "peacekeeper."



Late Nineteenth Century Metallic Cartridges

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Cal_45_LongColt.JPG

61. In its Navy Model 1889, Colt offered an even faster system. This pistol had the front of its cylinder fitted to a hinged arm or "crane." After firing, the entire cylinder swung out to the side of the revolver, away from the frame. All six cartridges could then be simultaneously pushed out using an ejector rod mechanism similar to that found in contemporary models made by Smith and Wesson.

REPEATING ARMS: RIFLES

62. These innovations in breechloading and metallic cartridges enabled yet another large leap in innovation—the repeating rifle.

63. Attempts to make firearms that could fire multiple shots have already been discussed briefly above with regard to revolvers. After all, a revolver is a form of "repeating" firearm. Indeed, Colt attempted to make revolving rifles, but these proved more prone to disastrous misfiring than did Colt's pistols and thus were not a general success.

64. There were other, even older experimental designs that attempted to create weapons capable of firing multiple shots in quick succession. One system that popped up periodically from the late sixteenth through the early nineteenth century, used "superimposed" loads. In the superimposed system, multiple locks (flint or percussion) are used along the same barrel to fire multiple charges that have been stack-loaded in the same barrel. In later variants, a single lock could slide up and down the barrel to discharge the different loads. This was a complicated and frankly terrifying design that was fraught with dangers. If a rear-loaded charge was accidentally fired with one or more charges still packed in the barrel in front of it, the results would be devasting. In all likelihood, the gun barrel would have catastrophically failed. Even when fired in

proper order, these weapons would have taken considerable time to reload as each charge had to be carefully aligned with each lock. Superimposed repeater weapons failed to develop a serious market, almost certainly due to issues of cost, safety, reliability and ease of use.

65. One notable experiment in repeating designs was an early seventeenth-century Danish marvel known as the Kalthoff gun which used a cylindrical tube mounted under the barrel that held multiple balls. This remarkable weapon also had a separate powder container in a hollowed section of the stock butt, and the whole gun could be primed and loaded by pivoting the trigger guard. As brilliant as the design was, it was exceptionally expensive to manufacture and challenging to maintain and repair. Kalthoff guns were carried by some elite royal guards of the Danish monarchy, but they failed to impress the military establishment of neighboring states and did not spread in appreciable numbers. Probably less than 200 were ever used by the guards themselves who abandoned the weapon in favor of the reliable, single-shot flintlock musket that regular Danish line troops had continued to use. Had the Kalthoff system been reliable and effective, these firearms would have been found in armories all over the world in the eighteenth century and would be common in museums today. In fact, only a few examples of these curiosities exist now.

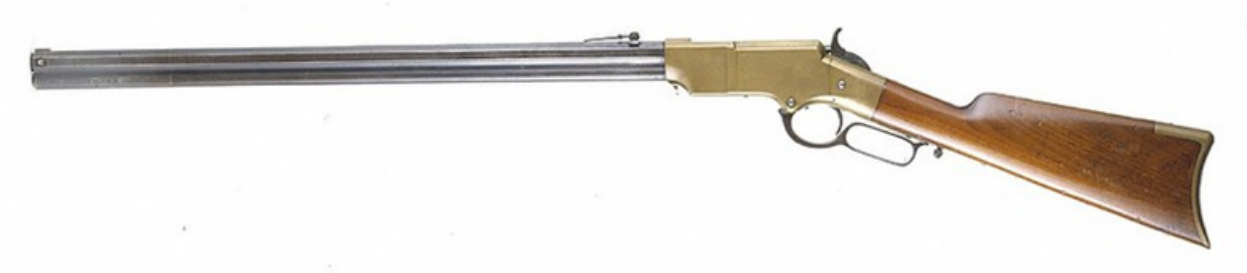
66. Other gunmakers claimed to be able to produce multi-shot long-arms (ie. not pistols) in the eighteenth century such as Joseph Belton of Philadelphia who tried to convince Congress to accept a contract with him to buy hundreds of his weapon. The offer was not accepted, and no examples of this particular repeating weapon exist. Today the Pitt-Rivers Museum in Oxford, England holds two pistols in its collection that were designed by Belton and a British partner, William Jover. The museum archivists believe these pistols were built in the UK sometime after

1784. They show that Belton and Jover merely copied the old-superimposed design noted above, so it is a reasonable supposition that Belton's earlier American plans followed the same principle.

67. Advertisements for repeating firearms from the eighteenth century admittedly exist too, but advertisements of this era are famous for remarkable and dubious claims. Eighteenth century ads for medicinal cure-alls are quite entertaining to read today, but they do not offer proof that effective and reliable medicines actually existed in that era.

68. Effective repeating long-arms (or pistols as in the case of Colt, already reviewed above) had to await the industrial revolution in America.

69. After precision industrial techniques had been developed, Benjamin Tyler Henry was able to produce a truly effective repeating rifle in 1860. It employed a cartridge which evolved, in part, out of Smith and Wesson's work with pistol cartridges in a failed earlier pistol design known as the "Volcanic." The Henry Rifle had a special tube attached to the weapon directly below, and in line with, the barrel. This tube, known as a "magazine," held a remarkable *fifteen* rimfire cartridges. At .44 caliber, the bullet in these cartridges was much smaller than those used in most muzzle-loading rifles of the time, but when fired from the weapon Henry built for it, the projectile had a muzzle velocity of 1,125 feet per second, a relatively high speed.



A Henry Rifle

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:NMAH-2004-26295-12.jpg

70. The Henry Rifle had an extraordinary rate of fire. By simply shoving the trigger-guard lever down and forward, a spent casing from the gun's barrel was ejected through the top of the breech, a fresh cartridge slid into the lifting mechanism, and the hammer was cocked back in a firing position. Snapping the lever back into place pushed the new cartridge up and into the breech, ready to be fired. This lever-action design prepared a bullet for firing with one smooth and simple motion, requiring no cartridge biting, no ramrods, and no fumbling for percussion caps. Unlike the three shots a minute that might be hoped for from an exceptionally quick infantryman armed with a muzzle-loader, trials demonstrated that an average shooter could discharge a Henry rifle once every 3 seconds. Reloading a Henry was a slower proposition as each cartridge had to be manually slid one-by-one into the tube magazine.

Reloading the Henry Rifle

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Henry_rifle_operation_03_loading_up_the_cartridges.jpg

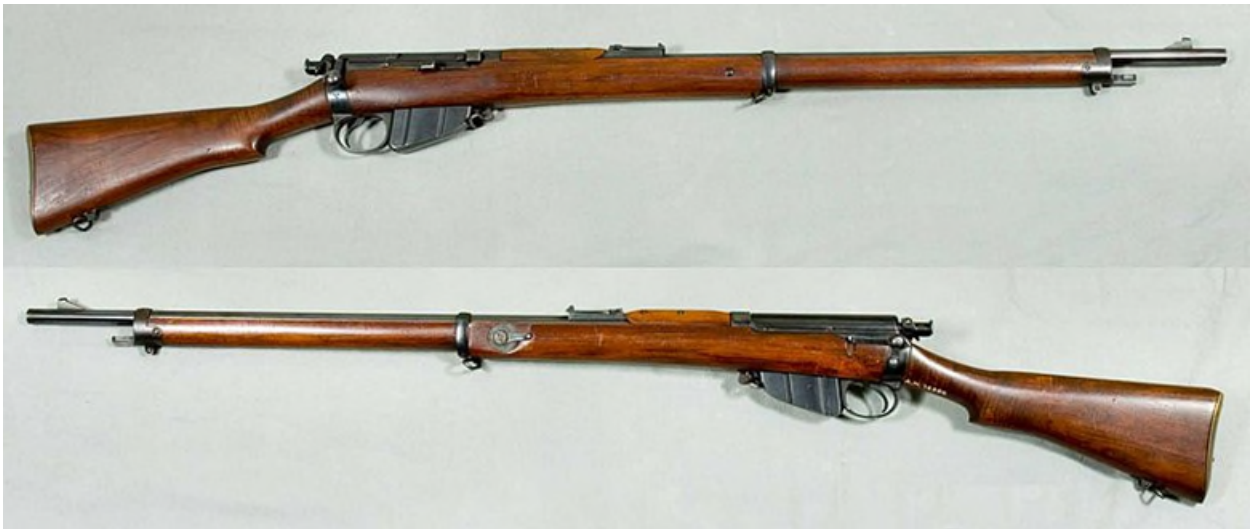
71. Henry rifles were in production by the start of the American Civil War but had an exorbitant price and thus did not see much combat. By the end of hostilities, the War Department had only bought 1,731 of the guns. Consider that in comparison to the over two million single-shot, muzzle-loading rifles built and purchased by the Union and Confederacy during the conflict.

72. A different repeating weapon that was somewhat more popular in the American Civil War was the Spencer rifle, also patented in 1860. Like the Henry, the Spencer employed a magazine tube, but this feature was set in a different location, behind the lock hidden in the butt of the gunstock. The shorter space of the butt and the larger bore/cartridge size only allowed seven cartridges to be loaded at a time but could be reloaded much quicker than a Henry by use of special pre-loaded cartridge tubes. Officially, the War Department bought almost 112,500 Spencer repeaters for use in the Civil War.

73. Meanwhile, back in Europe the development of "bolt-action" rifles was proceeding. Earlier in 1836, One of Pauly's proteges, Johann Nikolaus von Dreyse of Prussia had developed a breechloading lock that came to be known as the "bolt-action" lock for its similarity to a door lock. In later decades gunsmiths came to understand that these bolt action mechanisms could withstand a remarkable amount of pressure and thus allow for very powerful, longer-ranged cartridges to be introduced. One particularly successful example would be the French Chassepot Rifle Model 1866.

74. Like so many weapons before it, the Chassepot was single-shot but by the 1880s, several European nations were adding small magazines to bolt-action rifles so that they could fire more shots quickly in an emergency, much like the lower-powered repeaters of the US Civil War had done. In some cases these magazines were tube magazines, in others they took the form of a cavity directly underneath the bolt mechanism. One of the more remarkable magazine

innovations was adopted into the design of the British Lee-Metford of 1888 which had a box-shaped 8-round magazine that was normally fixed just below the bolt. It could be entirely detached from the weapon in order to make cleaning the firearm an easier task. Soldiers usually carried a second, pre-loaded magazine as part of their gear and if need be, they could quickly reload the rifle by simply removing the first magazine when it became empty and replacing it with the second one. This technology became increasingly popular in the following century and detachable magazines are now a standard feature on many, if not most, firearms today.



A Lee-Metford Rifle. Note the magazine extending out of the stock directly in front of the trigger.

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Lee-Metford_Mk_II_-_AM.032034.jpg

SMOKELESS POWDER

75. In 1884, Paul Vielle of France developed a new propellant that would quickly replace the basic gunpowder formula that had been pushed down gun barrels for nearly 600 years. The new material, which he called "Powder B," was nicknamed "smokeless" powder for reasons noted below. Because it was lighter in color than charcoal-based powder, people began

to refer to the older powder as "black powder." As one might guess from the name, smokeless powder produced significantly less smoke than older gunpowder, was also a more efficient propellant, and left less residue in the barrel.

76. A cartridge made with smokeless powder could be blown down a barrel at a much faster rate than one made with the old black powder. The force that a projectile has on an object when it impacts with it is a combination of both mass and speed. Gunmakers knew that a small bullet travelling at a relatively higher velocity would be just as capable of inflicting a similar level of injury as a large bullet travelling slower. Cartridges filled with smokeless powder could thus employ smaller caliber bullets, but these travelled significantly faster (over 2,000 feet per second when leaving the muzzle) and thus tended not to drop as much in flight. This would make a new generation of these "high-powered" rifles more accurate in the hands of the average shooter. Their cartridges also generally used a percussion cap set into the middle-rear of the cartridge ("center-fire") instead of the rim as heavily-loaded rimfire cartridges tended to tear themselves apart during firing.

MACHINE GUNS

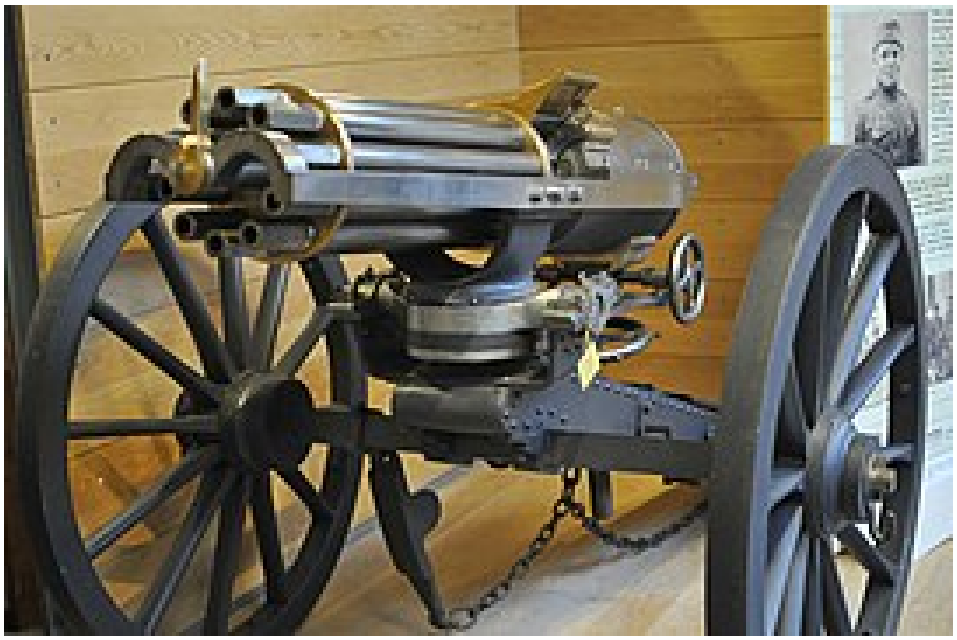
77. Like so many nineteenth-century firearm developments already discussed, the machine gun had older ancestors that attempted to accomplish similar tasks or work upon similar principles. The late fifteenth century saw the advent of "organ guns," so called because of their visual similarity to church organs. These devices consisted of multiple barrels fixed to a large stock, or more often to a wheeled carriage that needed horses to move any appreciable distance. They were made so that a single ignition traveled through passages cut in the rears of the barrels, firing each in succession. Others married multiple barrels to the superimposed system noted above in order to throw out dozens of shots. These devices must have been as cumbersome to

employ and as slow to reload as they were dangerous to fire and spectacular to watch. Like other experiments noted above, these organ guns failed to catch on in a meaningful way.

78. James Puckle's 'Defence Gun' was an early eighteenth century tripod-mounted oddity that underwent trials with the British military in 1717. It had a single-barrel fitted with a rotating cylinder, sort of like a big, long-barreled revolver. In theory, this thing was supposed to work a bit like a machine gun and fire its nine round cylinder rapidly before being speedily reloaded with a fresh cylinder. Potentially the weapon might have been capable of making dozens of shots per minute. However, the British military rejected the temperamental device because of its failure to fire consistently. Puckle continued to try to market the gun for a few years, but failed to attract investors and the project was a financial failure. Had the weapon actually functioned as promised, the story would have been different.

79. However, once again, with the advent of modern industry in the nineteenth century, new possibilities opened up. In 1861, Richard Gatling patented a hand-cranked, revolving, rapid-fire weapon that is widely credited as the first truly successful "machine gun." The term "machine gun" generally refers to a relatively complex (hence "machine") weapon capable of very rapid fire. Richard Gatling's gun employed a revolving mechanism and grouped a half dozen barrels together. Each barrel was fitted with its own breech mechanism and being quite large, the whole thing rested on a large-wheeled carriage, not unlike an artillery piece. The first Gatling Guns used a loose ammunition hopper, but this was later replaced with a detachable magazine system set above the breech. These were of various shapes, including a round "drum" design and a flat, straight magazine anticipating those found on later automatic and semi-automatic rifles. As each barrel revolved past the magazine, it picked up a cartridge that was then fired at the bottom of the rotation cycle. The Gatling could be fired as quickly as the handle was

cranked and empty magazines were replaced. One version, the Model 1883, was capable of firing as many as 1,500 shots per minute. Impressive as this was, the weapon was limited by its size. It was a large, complex device that usually needed a crew of three to four men to operate. It also was largely immobile without a team of horses and their teamsters to move it. George Armstrong Custer had seen these weapons slow his cavalry down significantly and he knew they could not transverse certain rough terrain, so he controversially left several regimental gatling guns behind when his forces set out for the Little Bighorn on June 22, 1876.



A Gatling Gun

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Gatling_gun,_British_1865_(16837609147).jpg

80. The Gatling, however, and other similar models like it, would be eclipsed in a few short years by even deadlier weapons. Rather than relying upon cranks or handles to drive the firing system the next generation of machine guns would be fully automatic. Simply pressing a trigger caused the gun to spit out a rapid, continuous spray of bullets.

81. These newer machine guns accomplished this task through somewhat different principles. In each method, a by-product of the cartridge's explosion drove the mechanism of the gun.

82. Perhaps the most lasting and revolutionary of this new class of firearms was developed by American inventor, Hiram Maxim. In the early 1880s, he began trying to design an automatic firearm after reportedly being advised that the best way to get rich quick was to invent something to allow Europeans to kill each other more easily.

83. When the propellant in any given cartridge is ignited, the explosion does not travel exclusively down the barrel, but initially pushes outward in all different directions. The metal barrel and the breechblock redirects much of this power to drive the bullet toward the muzzle. Some of this energy travels in the opposite direction, however, and this shoves the gun backwards into the shoulder of the firer. Such recoil is an old and unwelcome feature of most firearms.

84. In 1884, Maxim designed a machine gun in which the firing action was driven by each shot's recoil. The backward thrust of a shot pushed both the barrel and the breechblock slightly to the rear, opening the latter long enough to allow the empty cartridge to fling itself out of the gun. Fresh ammunition, made up of metallic cartridges set into a cloth "belt" was fixed and ready to be fed into the side of the breechblock. Besides throwing open the breechblock, the force of the Maxim Gun's initial shot also operated a mechanism that pulled the belt into the breechblock and lined up a fresh round. After the barrel had been cleared, a recoil spring helped push the breechblock back in place, driving a fresh cartridge from the belt into the breech and firing it too. This process repeated itself as long as the weapon's trigger was held down. The Maxim could fire at a rate of about 500-600 rounds per minute. The weapon was more portable

than a Gatling gun, but still weighed in at about 60 pounds, not counting ammunition. In the field the Maxim often had a crew of four men and was mounted on a small-wheeled carriage.

Hiram Maxim and His Invention

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Metralhadora_1884.jpg

85. As popular as recoil-operated Maxims became and would continue to be, a second machine gun using a different system of automation made an appearance at the close of the century. Instead of relying on the simple recoil power of the shot, American inventor John Browning tapped into the expansion power of the gas created when the cartridge's propellant ignited. Browning realized that more of the propulsion "gas" was released upon firing a cartridge than was actually needed to drive the bullet. He designed a system that siphoned off a little bit of

this expanding gas to drive a lever that could expel an empty cartridge and load a fresh one. In many ways his weapon operated similarly to Maxim's but it used expanding gas to reload each shot rather than recoil force. The end result was the Colt Model 1895 Automatic Machine Gun. Browning's gun provided a slightly lower rate of fire, about 400 rounds per minute, but at 35 pounds it was lighter and more portable than the Maxim machine guns. It usually only required a crew of two to operate effectively.

86. Most new successful firearms of the twentieth century would employ some variation or combination of recoil and/or gas operation systems.

TURN OF THE TWENTIETH CENTURY: SEMI-AUTOMATIC PISTOLS

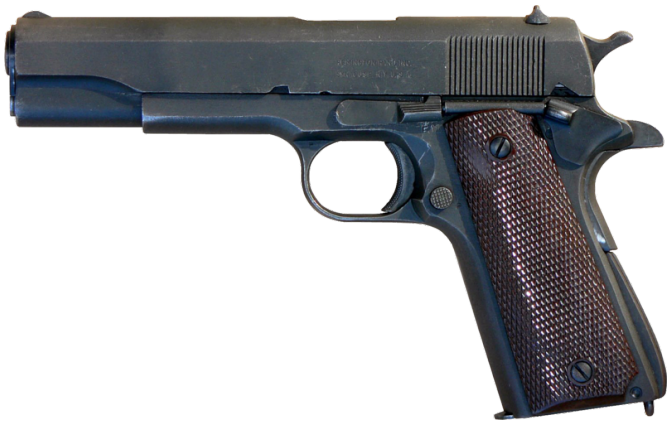
87. The pistol continued to be an object of experimentation and a new class of handguns that could keep firing without being cocked after each shot was developed around the turn of the twentieth century. Because the trigger still had to be pulled for every round fired, these new handguns were not considered fully automatic like a machine gun, but rather "semi-automatic."

88. In 1893, German inventor, Hugo Borchardt designed an innovative gun for the firm Ludwig Leowe that contained some of the key elements found in modern semi-automatic pistols. In particular, the weapon had a clever detachable magazine system hidden in the pistol grip. Up to 8 cartridges were stacked up with one on top of the other and pushed upwards into the breechblock by a spring, much like the magazine-fed bolt action rifles being deployed around the same time. In this case, however, the shooter was relieved of the duty of rechambering each shot. This job was instead performed by a heavy spring mechanism set in a semicircular housing in the rear of the pistol behind the magazine. The spring fixed to a hinged arm or "toggle" designed to bend in an upward motion. The recoil from the first shot drove back the breech block, recocked the firing pin, and threw out the empty cartridge, all before the spring reasserted itself and pushed the bolt back forward. As it reclosed, it picked up a fresh cartridge

from the magazine and drove it into the firing chamber. In many ways, the system was very similar to that used in the Maxim, except the shooter had to pull the trigger after each shot.

89. The Borchardt was a little delicate for field use and clumsy to handle. Still, it was successful enough to drive a flurry of competitors into designing similar guns, including a variant produced by the Mauser Company in 1896, and another model designed by George Luger. This pistol was named the "Parabellum," but more famously came to be known as the "Luger." Luger kept the hinged toggle arm and the pistol-grip magazine of the Borchardt but changed many other elements of the gun making it more ergonomic. He also modified the pistol to use a slightly larger, 9mm, cartridge. The weapon was adopted by the German army in 1908.

90. In the late 1890s, Browning began putting together his own prototypes of semi-automatic pistols. The guns used the detachable magazine system set in the pistol grip like the original Borchardt. But the main recoil spring was not behind the bolt but rather ran alongside the barrel. One of these designs, the Colt Model 1911, chambered for a large .45-caliber cartridge (larger than the 9mm), would remain the standard U.S. Army service pistol right into the 1980s.



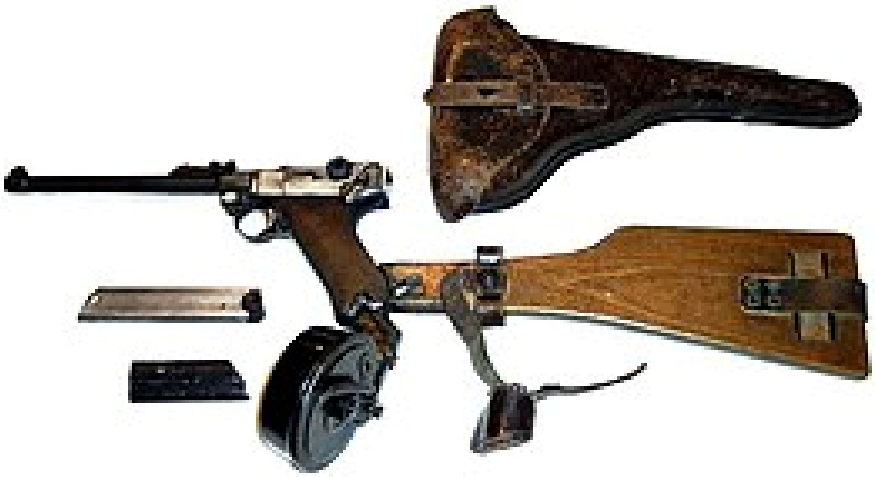
A Colt M1911

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:M1911A1.png

91. Most new semi-automatic pistols today, whether made by FN, Colt, Beretta, or Glock, use a firing action design not far removed from Browning's originals. Standard magazine capacity, however, expanded drastically in the late twentieth and early twenty-first century with semi-automatic pistols now capable of holding fifteen cartridges or more in their magazines. The original M1911 could hold seven cartridges in the magazine and one in the chamber for eight. The original Glock-17, introduced in 1982, could hold twice as many rounds in its magazine.

TWENTIETH CENTURY: SUBMACHINE GUNS

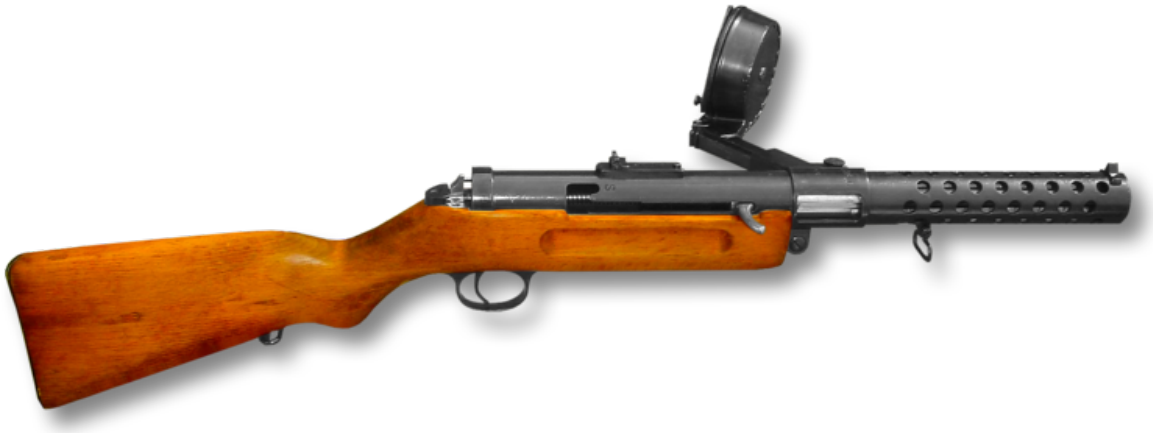
92. Before and particularly throughout World War I, considerable efforts were made to produce a lighter, more portable, yet durable automatic weapon. For example, fully automatic versions of both the Colt Model 1911 and Luger were experimented with. In the latter case, a special Luger pistol, the LP08, had been designed for artillery personnel and fitted with an 8-inch barrel, a carbine shoulder stock, and a special thirty-two-shot snail-shaped drum magazine that extended out below the handgrip. This "artillery Luger" was intended to function like a carbine (short rifle) however it was not particularly effective when experimentally converted to fire in a fully automatic manner. In automatic firing weapons, the recoil of one shot often spoils the aim of the next. In a heavy, fixed weapon like the Maxim this was less of a problem, but the lightweight experimental Luger machine gun/pistol tended to spray secondary shots off target. This phenomenon of "muzzle rise" has in fact been an ongoing challenge to designers of lightweight automatic weapons.



An "Artillery Luger"

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Arty08.jpg

93. A more satisfactory firearm was developed in 1916, by a designer for the Theodor Bergmann Armament Company. The gun cleverly used the same 9mm cartridge and snail magazine as did the artillery Luger, but it was designed from the ground up as a two-handed weapon. This allowed for good automatic-fire control. The firearm was designated "Machine Pistol 18, I," when adopted by the German military in 1918, but came to be known simply as the "Bergmann." With the advent of this firearm, individual soldiers now had access to a portable, easy-to-reload, effective, fully-automatic weapon.



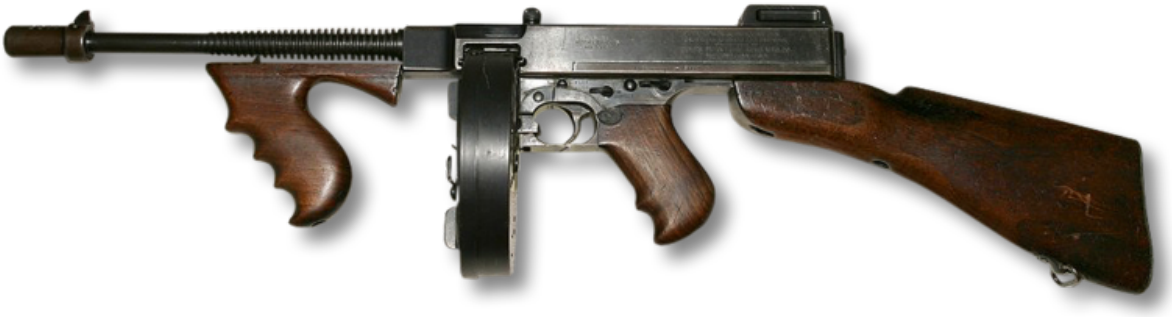
A Bergmann Machine Pistol 18

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Bergmann_MP18.1_noBG.png

94. American designers were likewise trying to develop easily portable automatic weapons around the same time. During World War I, retired U.S. Army general, John Thompson, privately put together a team of engineers to develop a lightweight automatic weapon for use in the war. He originally envisioned a larger caliber weapon, but when his designers advised using pistol cartridges Thompson reportedly stated: "Very well! We shall put aside the rifle for now and instead build a little machine gun. A one-man, hand held machine gun. A trench broom!" Thompson subsequently coined the term "submachine" for his gun.

95. Although the weapon came to be widely manufactured by Colt in 1921, the US Army initially showed little interest in it. Though it retailed for a whopping $200 in the 1920s, the new gun managed to find a civilian "niche market," when organizations of illegal alcohol dealers began using them in distribution disagreements. As a result, the "Tommy Gun" or "Chicago typewriter" made a big splash in the U.S. popular imagination. Eventually the American and British armies adopted the gun as well.

96. The Tommy gun differed from its continental cousins in a few notable respects. Like the M1911, it used a larger, .45 caliber cartridge, rather than the 9mm preferred in Europe. It was more rugged and dependable. Nor did it use a single-piece carbine-like wooden stock, but instead had a metal frame with a separate wooden pistol grip and buttstock. There was even a second pistol-type grip set closer to the muzzle for the shooter's other (non-trigger finger) hand. The double pistol grips improved fire control. Between these handholds, under the breech was a port that could accept several different sized magazines.



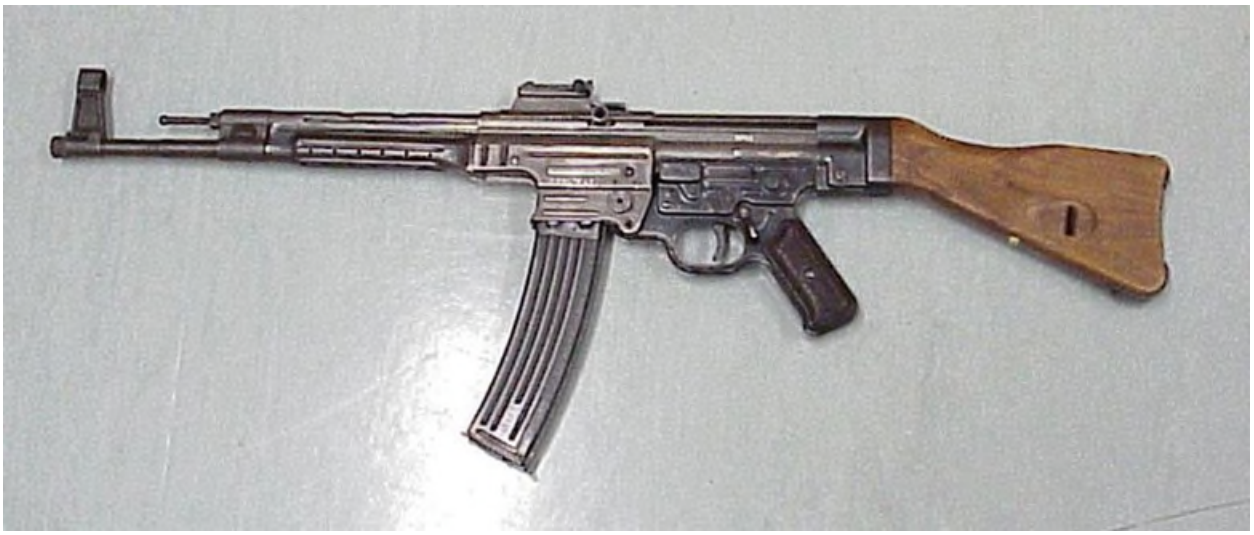
A Thompson Submachine Gun

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Thompson_submachine_gun_noBG.png

97. Experimentation continued with submachines guns for military use after and through World War II, resulting in many new and successful models. Nevertheless, as successful as these compact automatic weapons had been, they would not predominate on the battlefield. Most regular line soldiers were not issued guns like these. Even in World War II, most soldiers around the world used around heavy bolt-action rifles that were little changed from the late nineteenth century. This was largely because submachine guns used pistol ammunition, which lacked the long-range accuracy and hitting power offered by longer-barreled, heavy-caliber rifles. In the

second half of the century, submachine guns became increasingly resigned to use by specialized military personnel, police, and more contemporary distributors of controlled substances.

98. The weapon that eventually caused the demise of both the long-range bolt-action rifle and the speedy submachine gun was the automatic, "storm," or "assault" rifle (there is debate over the best name) that came to incorporate many of the best (or worst, depending upon your viewpoint) features of both. These weapons were developed at the close of World War II by Germany which introduced a weapon called the "Sturmgewahr" (Storm Rifle) of 1944 or StG44 for short. It used a relatively high-powered cartridge, but could fire either semi or fully automatically. While a bolt-action rifle might hold eight or ten rounds, the StG44 utilized a large, 30 round, detachable magazine. The weapon gave German soldiers unprecedented firepower but fortunately it was introduced too late in the war to make a significant difference in the outcome.

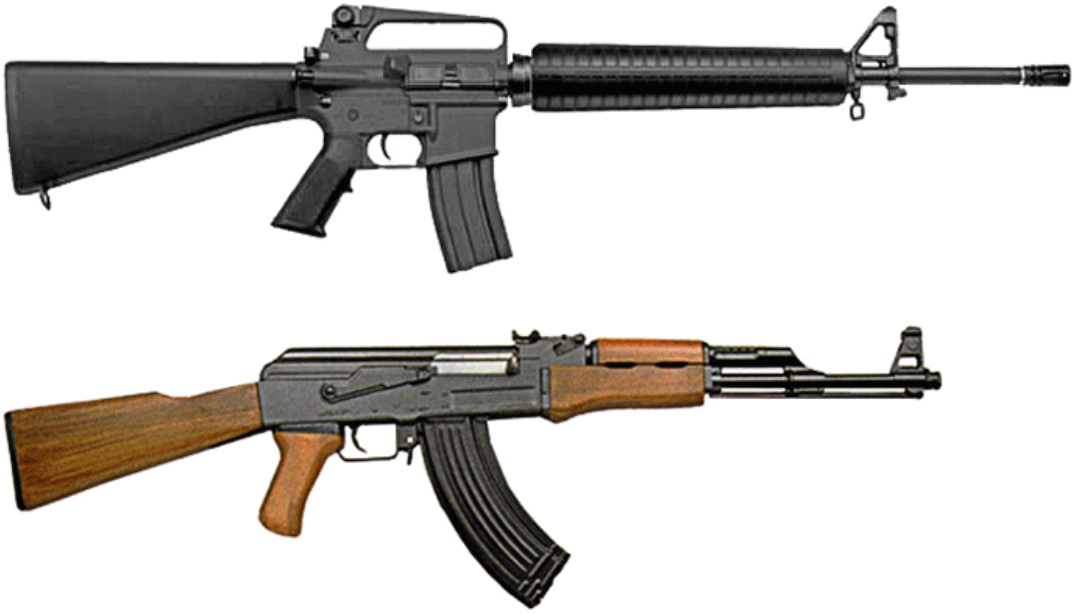


A StG44 Sturmgewahr

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:Sturmgewehr_44.jpg

99. After WWII, this type of weapon was widely copied throughout the Cold War with similar firearms proliferating through the world's armed forces. The most famous is the

Automatic Kalashnikov of 1947 or AK-47, which was designed by Mikhail Kalashnikov of the Soviet Union as a rugged, more reliable version of the German StG44. The basic design of the AK-47 has been copied and tweaked almost endlessly over the decades and it is estimated that over one hundred million weapons based on this design have been produced across the world. The M-16 was developed in the United States based upon similar principles, perhaps emphasizing precision and accuracy over reliability. These weapons typically sport a 20 or 30 round detachable magazine, a pistol grip like the Thompson, and fire powerful high-speed ammunition. For example, the M-16 could propel its 5.56mm ammunition with an astonishing muzzle velocity of over 3,000 feet per second.



A M-16A2 (top) and AK-47 (bottom)

Courtesy of Wikimedia
https://commons.wikimedia.org/wiki/File:M16_and_AK-47_comparison.png

THE PRESENT

100. The firearm that exists today bears some similarities with its ancestors but holds a distinctly different class of lethality. Firearms today still propel a projectile down a barrel by means of expanding gas, but the difference largely stops there. The ease of use, rate of fire, muzzle-velocity, power, and accuracy are all vastly different. Setting fully-automatic weapons aside, as these are restricted for civilian use, it can still be safely stated that the modern semi-automatic firearm is a remarkably lethal device in and of itself. In addition to the semi-automatic pistols, like the Glock 17 noted above, there are a wide variety of semi-automatic rifles and carbines on the market. Many of these firearms are designed in a style similar to the AK-47 or M-16 noted above. Colt's civilian version of the M-16 was called an AR-15, the letters being a nod to the Armalite Company that first developed the rifle. This weapon was very similar to the military version except that it did not have the capacity for automatic fire. Weapons styled upon the AR-15 or AK-47 design are very popular and estimates of their numbers in the United States range into the millions. A person armed with one of these highly-accurate rifles or carbines can fire off 30 rounds of highly lethal ammunition as fast as the trigger can be pulled. In a mere matter of seconds, the empty magazine can be replaced with a full one and the weapon is ready to fire again. This is a far cry from the single-shot muzzleloaders that dominated the period when the United States was founded.

101. A modern semi-automatic pistol or rifle is also reasonably inexpensive in comparison to older weapons. A muzzle-loading, single-shot Springfield Rifle in 1861 cost $15, which is about 14% more than an enlisted Union soldier's monthly pay of $13 per month. Today a civilian Colt M-4 Carbine (a high-quality AR-style rifle) retails for $1099. This is about 27% *less* than the roughly $1500 a low-ranking enlisted soldier in the US Army earns per month.

IN SUMMARY

102. This review has demonstrated that the development of firearms in the United States and elsewhere in the world was a long and laborious process. The firearm that exists today is a significantly different weapon than it was at the time of the founding of the republic.

103. The supposition that there were effective and reliable rapid-fire weapons that long pre-dated the founding of the United States of America, or that were even contemporary to the founding, is ahistorical. The idea that the founders would have been very familiar with repeating firearms is inaccurate.

104. During the war that won the USA its independence from Britain, the dominant weapon was the smoothbore, single-shot, flintlock musket. Single-shot rifles also existed and saw service in that conflict. However, rifles were usually used by skirmishers and did not play a deciding role in the war.

105. The percussion lock, which initiated much swifter movements in the development of firearms, was not patented until 1807, thirty-three years after the USA declared its independence. One cannot begin to speak of a reliable multi-shot weapon until the advent of Colt's percussion cap and ball revolver, patented sixty years after the birth of his nation.

106. The weapons of the American Civil War and the era of the Second Founding were significantly advanced in comparison to the flintlock musket and included successful repeating designs. However, these were still rare enough that the vast majority of the fighting was conducted with single-shot, muzzle-loading rifles. These weapons remained significantly less lethal than the firearms of today.

107. Detachable magazines, semi-automatic, and automatic firing weapons had to wait until the last fifteen years of the nineteenth century to be invented. It was not until the

appearance of the Artillery Luger of WWI, at the earliest, that one might begin to speak of high-capacity, portable, reliable, quick-reloading, rapid-firing firearms. Even this weapon was usually issued with only a single magazine that was quite difficult to re-load. One would probably have to wait until the appearance of the Bergmann or Thompson submachine guns to begin to make valid comparisons to the sort of devastating weapons used in mass shootings today, such as the ubiquitous AR-15 styled rifles.

108. The modern semi-automatic pistols and rifles that dominate the American civilian firearms market today are remarkably powerful and lethal weapons. They are technically sophisticated and deadly but easy to use and reasonably inexpensive to purchase. These firearms offer an entirely different level of lethality in comparison to the weapons that were available to the public at the time the United States of America was founded or even those that existed during the era of the Second Founding.

Dated this 6th day of February, 2023.

s/ Roger Pauly
Roger Pauly

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